INDOOR AIR QUALITY ASSESSMENT

Hull School Administration Building
7 Hadassah Way
Hull, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
January 2004

Background/Introduction

At the request of Kevin O'Brien, Public Health Director for the Hull Board of Health, the Bureau of Environmental Health Assessment (BEHA) conducted an evaluation of the indoor air quality at the Hull School Administration Building (HSAB), 7 Hadassah Way, Hull, Massachusetts. On September 30, 2003, Cory Holmes, an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality program (ER/IAQ), conducted an assessment of the building. Mr. Holmes was accompanied by Joyce Sullivan of the Hull Board of Health and Mr. O'Brien. Concerns about skin rashes and general indoor air quality complaints prompted the assessment.

The HSAB is a one-story red brick building that was constructed in 1948 and renovated in 1996, prior to occupation by the Hull School Department (HSD). The building contains office space for HSAB staff. Several rooms are occupied by the Hull Family Network, a private day care provider. Windows appeared to be original, single-paned, wooden sash design. Windows are openable throughout the HSAB, however occupants reported many are difficult to open.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

The HSAB has a staff population of approximately 20 and may be visited by up to 100 members of the public daily. Tests were taken under normal operating conditions. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million of air (ppm) in four of fourteen areas surveyed, indicating adequate ventilation in most areas of the building. Mechanical ventilation is reportedly provided by an air-handling unit (AHU) located in the attic. Supply air is distributed via ductwork connected to ceiling mounted air diffusers (Picture 1). BEHA staff could not gain access to the AHU at the time of the assessment. Town/school officials could not confirm whether the AHU is capable of introducing fresh air. Exhaust/return ventilation is provided by wall-mounted grills that are ducted back to the AHU. Several of these vents were blocked by bookcases and file cabinets (Picture 2). In order for exhaust ventilation to function as designed, vents must remain free of obstructions.

Thermostats control the ventilation system. These thermostats have fan settings of "on" and "automatic". During the assessment, thermostats were set to the "automatic" setting (Picture 3). The automatic setting on the thermostat activates the system at a preset temperature. Once the thermostat reaches a preset temperature, the system is automatically deactivated.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation, the mechanical supply and exhaust systems must be balanced to provide an adequate amount of fresh air to the interior of a room, while removing stale air from the room. The date of the last system balancing was not available at the time of the assessment. It is recommended that existing ventilation systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires that each room in an office have a minimum ventilation rate of 20 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, please see Appendix A.

Temperature readings in occupied areas were measured in a range of 72^{o} F to 74^{o} F, which were within the BEHA comfort guidelines during the assessment. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building the day of the assessment ranged from 44 to 50 percent, which was within the BEHA recommended comfort range. The BEHA recommends that indoor air relative humidity is comfortable in a range of 40 to 60 percent. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is common during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water damaged wall plaster was noted in several rooms of the HSAB (Pictures 4 and 5). It is likely that this water damage is a result of water penetration through breaches in the building envelope (e.g., roof, exterior walls, door and window systems and foundation). Breaches of the building envelope identified by BEHA staff include the following:

- Holes/spaces were observed on the exterior brick wall where mortar is missing/damaged (Pictures 6 and 7).
- Severely water-damaged wood exists along roof eaves and doorframes (Pictures 8 and 9).
- Spaces and missing/damaged caulking were observed around window frames in the building exterior (Picture 10).
- Roof edges are not equipped with a gutter/downspout system. Depending on wind and weather conditions, roof rainwater can run down the side of the building and penetrate through holes/spaces in the mortar or water can pool on the ground along the foundation.

The splashing of rainwater along the edge of the building wets the base of exterior walls. This repeated moistening has created a characteristic stain around the building. North-facing corners and walls of this building are particularly vulnerable to moisture for extended periods of time, since the brick is not dried out by exposure to direct sunlight. Excessive exposure of exterior brickwork to water can result in damage over time. During winter weather, the freezing and thawing of moisture in bricks can accelerate the deterioration of brickwork. Growth of moss on exterior brickwork (Picture 11) is also an indication of chronic wetting of building components. Moss growth can also damage building components, as it holds moisture against brickwork.

- Trees and other plants are growing against the building (Picture 12). The growth of roots against the exterior walls of a building can bring moisture in contact with building materials. The roots may eventually breach the building envelope, causing water damage and subsequent microbial growth. Ivy is also covering exterior walls. Clinging plants can cause water damage to brickwork through insertion of tendrils into brick and mortar.
- Water-stained ceiling plaster was seen in the hallway outside the superintendent's office, which is evidence of a roof or plumbing leak. As discussed, water-damaged building materials can provide a source for mold growth, especially if wetted repeatedly.

Each of these conditions compromises the integrity of the building envelope and can provide means for water to penetrate the building. Repeated water damage to porous building materials (e.g., wallboard, ceiling tiles, carpeting) can result in microbial growth. The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within

24-48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur.

Other Concerns

As mentioned previously, occupant skin rash concerns and general indoor air quality complaints prompted the assessment. According to building staff, new heating/ventilation system components were installed in the attic during the summer. Occupants reported that during the heating/ventilation system installation, contractors removed fiberglass insulation from the attic and stored it loosely on the carpet in the main hallway. The insulation was removed upon project completion; however shortly after the removal, employees complained of skin rashes, eye irritation, and coughing. Exposure to fiberglass particles, as well as excessive dust, can serve as a skin and respiratory irritants. Accumulation of dust on flat surfaces was noted at the time of the assessment. BEHA staff recommended that all surfaces be thoroughly cleaned with a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner. These surfaces should also be wet wiped to remove accumulated dust and/or debris.

Conclusions/Recommendations

The conditions noted at the HSAB raise a number of indoor air quality issues. General building conditions, maintenance, design, age and ventilation equipment operation, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required.

The approach consists of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Continue to use the HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces to eliminate dust and remove residual debris associated with renovation work.
2. Contact the School Department's ventilation contractor to determine whether the system introducing outside air.
3. Operate both supply and exhaust ventilation continuously during periods of building occupancy independent of thermostat control. Set thermostat to fan "on" setting.
4. Remove all blockages from exhaust/return vents to ensure adequate airflow.
5. Ventilation industrial standards recommend that mechanical ventilation systems be balanced every five years (SMACNA, 1994). Consult a ventilation engineer concerning re-balancing of the ventilation systems.
6. Adopt scrupulous cleaning practices. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices such as those mentioned above, (wet wiping and HEPA vacuuming) should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
7. Remove plants or relocate approximately five feet away from the exterior wall of the building to prevent water impingement.

8. Ensure all roof leaks are repaired. Examine the areas above water damaged ceilings for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
9. Seal open utility holes and spaces on exterior of the building. Repair water damaged plaster on interior walls.
10. Refer to resource manuals and other related indoor air quality documents for further building-wide evaluations and advice on maintaining public buildings. These materials are located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

The following **long-term measures** should be considered:

1. Consult with an architect and or general contractor regarding the integrity of the building envelope, primarily concerning water penetration through walls and around window frames. Examine the feasibility of repointing brickwork.
2. Consider installing gutters/downspouts to direct rainwater away from the building.
3. Consider repairing/replacing damaged wooden window/door frames to prevent water penetration.

References

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OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

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Picture 1

Supply Air Diffuser

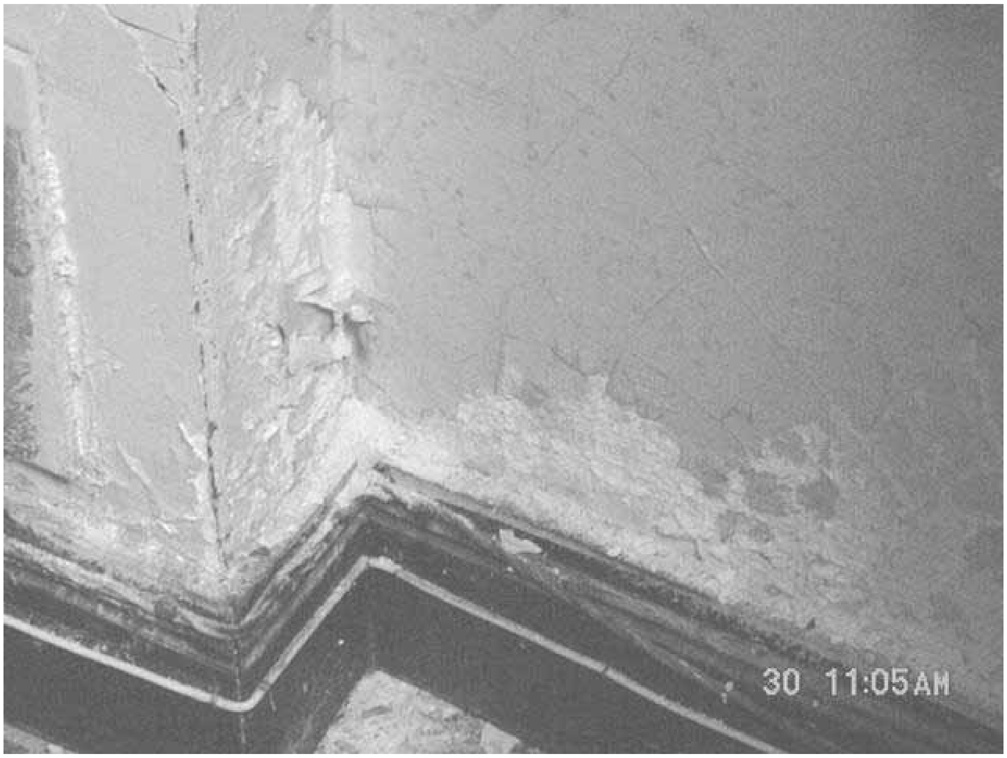
Picture 2

Exhaust/Return Vent Obstructed by Bookcase

Picture 3

Thermostat Fan Setting on "Auto"

Picture 4



Water Damaged Wall Plaster and Efflorescence

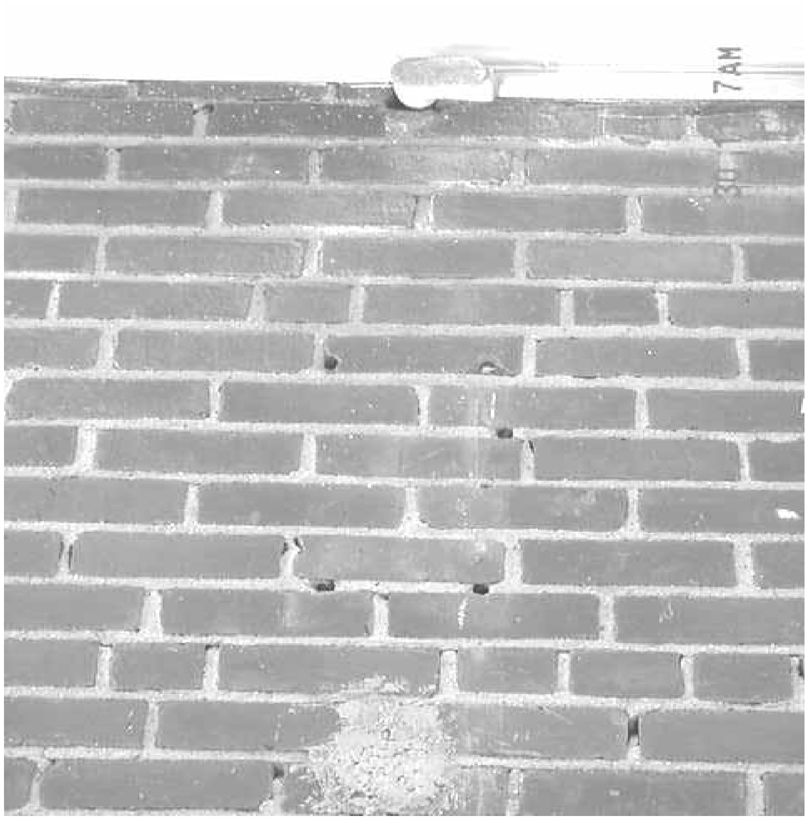
Picture 5

Water Damaged Wall Plaster

Picture 6

Missing/Damaged Mortar around Brickwork

Picture 7



Holes and Missing/Damaged Mortar around Brickwork

Picture 8

Rotted/Damaged Wood along Roof Eave

Picture 9

Damaged Wooden Door Frame

Picture 10

Spaces around Window Frames

Picture 11

Moss Growth between Bricks along Perimeter of the Building

Picture 12

Plants/Trees Growth against Building

TABLE 1

Indoor Air Test Results – Hull School Administration Building, Hull, MA September 30, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	420	68	46					Weather conditions: clear skies light breeze
Main Hallway	802	73	50					Thermostat-off, fan (auto)
M.I.S. Director	725	74	46	4	Y	Y	Y	Efflorescence wall plaster in office & closet
Assistant Superintendent Support	715	72	47	4	Y	Y	Y	Window AC-no filter, heavy efflorescence-corner wall/peeling paint, exhaust blocked by file cabinet
Assistant Superintendent Office	786	72	47	0	Y	Y	Y	photocopier
Hallway (Superintendent)								Water fountain-deactivated, water stained ceiling plaster
Kitchen	825	73	49	0	Y	Y		Water heater
Superintendent Secretary	778	73	46	1	Y	Y	Y	Small water stains ceiling
Superintendent	776	72	47	1	Y	Y	Y	Thermostat fan "auto"

*** ppm = parts per million parts of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results – Hull School Administration Building, Hull, MA September 30, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Women's Restroom					Y	Y	Y	
Men's restroom					Y	Y	Y	Exhaust vent not operating
Bookkeeper	762	72	48	1	Y	Y	Y	
Chief Business Finance Office	741	74	47	1	Y	Y	Y	
Business Office	799	74	48	1	Y	Y	Y	
Business Manager Office	783	74	47	1	Y	Y	Y	
Day Care Office	834	74	46	0	Y	Y	Y	Hole in wall-wiring
Hull Family Network	1048	74	48	2	Y	Y	Y	23 occupants gone 1 hr

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Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Perimeter notes								Spaces around window sills, missing/damaged mortar-bricks, damaged flashing along front of build, ivy growth, no gutters/downspouts, rotted wood-eves, back splash-moss growth on brick, plant growth-tarmac

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